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Simulating CO2 assimilation of two grassland competing species in a tropical mountain ecosystem

Brenner Silva and Jörg Bendix
University of Marburg, Germany (brenner.silva@students.uni-marburg.de)

The tropical mountain forest in the Andes of Ecuador is the second hottest biodiversity hotspot worldwide. At the same time, Ecuador suffers from the highest deforestation rate in South America where the natural forest is removed mainly to gain pasture land. Frequently, the planted pasture grass is overgrown by the southern bracken which leads to the abandonment of pastures and thus increases deforestation. This ecological problem holds for the San Francisco Valley in the SE Andes of Ecuador, where an experimental site of 1000 m^2 was established to understand the growth efficiency of bracken and its competitive strength in comparison to the pasture grass (Setaria spacelata), a C4-species. Vegetation cover and biomass have been continuously observed while a customized meteorological station has delivered data of the atmospheric, plant and soil conditions. A numerical model (the Southern Bracken Competition Model - SoBraCoMo) has been developed to simulate the potential growth of both competing species in terms of energy and mass exchange with the atmosphere. A first study using this model was carried out on the absorption of direct and diffuse radiation (Bendix et al. 2010) and in this second study the physiological performance is investigated. A SVAT-scheme, including the two-big-leaf approach, is considered, so that shaded and sunlit leaves require individual parameters. The required model parameters (optical and physiological plant traits) have been derived from intensive field and laboratory measurements.

The results of the photosynthesis and respiration modules were used to calculate net CO2 assimilation at leaf and canopy level. At leaf level the validation was conducted by means of independent measurements of daily course. Regarding the daily sum of net photosynthesis, less than 5% difference was observed between simulation and measurement for both species. Root mean square errors were 1.5 and 2.7 μmol CO2 m-2 s-1 for bracken and Setaria respectively, which points out to a good parameterization by our field and laboratory measurements.

Subsequently, the validated model was initialized with the annual course of meteorological conditions for 2008 in 10 minute intervals. Leaf area and root biomass were held constant, considering an average individual in the course of the year. The results were integrated and the annual productivity of the two species were compared. The grass Setaria was slightly more productive, assimilating 14% more atmospheric CO2 than the southern bracken. Observing the time series, this productivity was strongly reduced in the mid of the year mainly due to low radiation and temperature. The annual increase in total biomass yielded 5.9 kg per m^2 of the pasture grass Setaria and 5.6 kg per m^2 for bracken. This result contrasts with field observations on the abandoned pastures where the grass is outcompeted by bracken. The difference between model and field observations points out that other factors like cattle browsing and nutrient deficiency, including Phosphate, might be responsible for the competitive strength of bracken. A brief discussion is then made regarding the modelling approach, new observations in the experimental site and simulation results under current conditions and on the basis of predicted IPCC scenarios for the SE Andes of Ecuador.

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Reference. Bendix J, Silva B, et al. 2010. Int J Biometeorol, v.54. doi:10.1007/s00484-009-0279-3